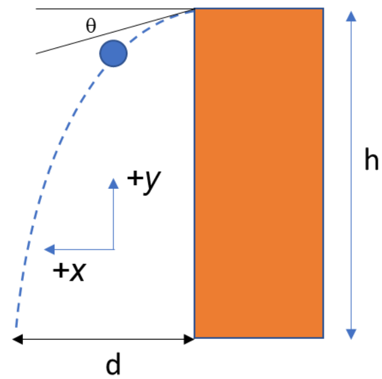
The next four questions pertain to the situation described below.

A ball with mass m =1.8 kg is thrown downward from the top of a building with height h = 16 m and initial speed v_0 at an angle θ with respect to the horizontal as shown in the figure. The x-component of the initial velocity v_{x0} = 23.4 m/s, and the ball hits the ground a distance d = 24 m from the building as shown in the figure.



1) How long is the ball in the air?

a. t = 1.81 s
b. t = 1.03 s
c. t = 4.78 s

2) What is v_{y0}, the y component of the ball's initial velocity?

a. v_{y0} = -19 m/s
b. v_{y0} = -13 m/s
c. v_{y0} = -26 m/s
d. v_{y0} = -11 m/s
e. v_{y0} = 0 m/s

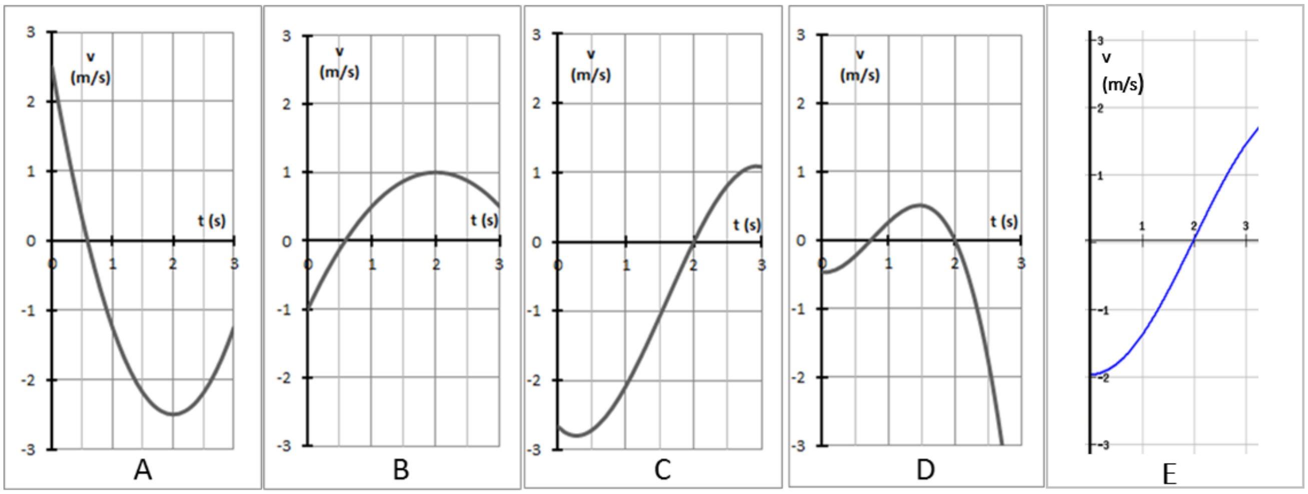
3) If the ball is thrown at the same angle, but with a greater speed, the ball would be in the air

a. a **shorter** time.
b. a **longer** time.
c. the **same** amount of time.

4) If the ball is thrown with the same speed, but horizontally (e.g. θ=0), it would hit the ground with

a. a **faster** speed than when it was thrown downward.
b. a **slower** speed than when it was thrown downward.
c. the **same** speed as when it was thrown downward.

The next two questions pertain to the situation described below.



A ball's motion is represented by the velocity time-graph above.

5) *Which of the velocity-time graphs best represents this statement?*

An object has zero acceleration at t=2 s. At t=2.5 s, it is moving in the positive direction and slowing down.

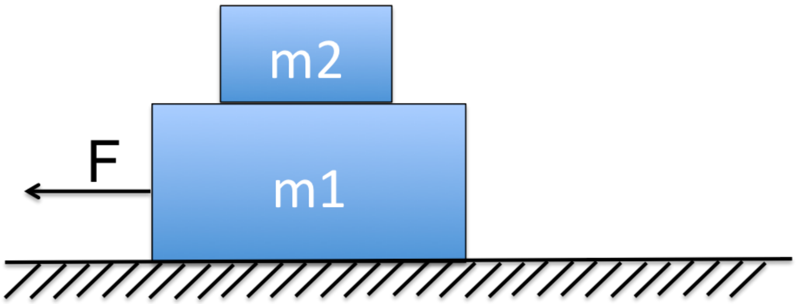
a. A
b. B
c. C
d. D
e. E

6) *Which of the velocity-time graphs best represents this statement?*

The object is moving in the positive direction and speeding up at t=1.75 s. The object has has negative acceleration at t=2.5 s.

a. A
b. B
c. C
d. D
e. E

The next three questions pertain to the situation described below.



A box of mass m_1 = 10 kg is placed on a frictionless surface. A smaller box of mass m_2 = 3 kg is placed on top of the larger box. The system of boxes is initially at rest. A horizontal force F is applied to the lower box, pulling it to the left as shown in the figure. The coefficients of static and kinetic friction between the two boxes are μ_k = 0.25 and μ_s = 0.29.

7) Initially, the two boxes are observed to move together (the small box remains on top of the large box). What is the direction of the friction force applied **by** the smaller box m_2**on** the larger box m_1?

a. to the left
b. to the right
c. there is no frictional force between the two boxes

8) What is the maximum force F_{max} that can be applied, before the small box begins to slide relative to the large box?

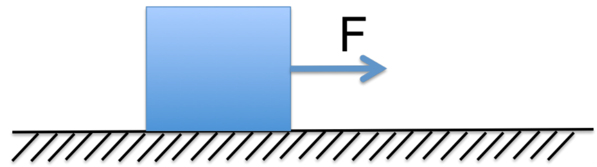
a. F_{max} = 37 N
b. F_{max} = 7.4 N
c. F_{max} = 32 N
d. F_{max} = 28 N
e. F_{max} = 24 N

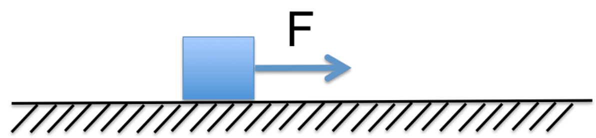
9) If the boxes start from rest, and a force F = 12 N is applied until the boxes have moved a distance of 2.5 m, what is the work done by friction on the **top** box m_2? (You may assume the two boxes move together.)

a. $W_{friction}$ = 6.9 J
b. $W_{friction}$ = 0 J
c. $W_{friction}$ = 21 J
d. $W_{friction}$ = -6.9 J
e. $W_{friction}$ = -21 J

The next two questions pertain to the situation described below.

A solid cubic box of mass $m = 4$ kg is pushed along a floor by a horizontal force $F = 12$ N. The box is observed to move with a constant velocity $v = 0.3$ m/s.





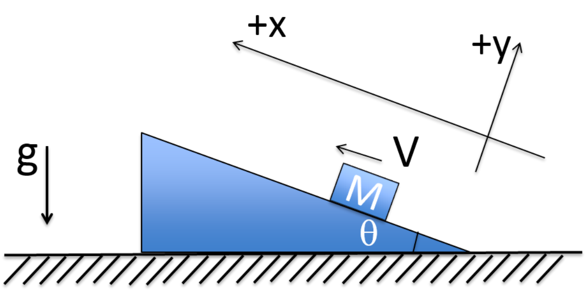
10) What is the coefficient of kinetic friction between the box and the floor?

a. $\mu = 0.0092$
b. $\mu = 0.15$
c. $\mu = 0.31$

11) A second box is made of the same material as the first box but is half the size of the first box in every dimension. Subject to the same force $F = 12$ N, the second box:

a. Moves with the same constant velocity as the first box.
b. Moves with a constant acceleration
c. Moves with a constant velocity eight times that of the first box.

The next three questions pertain to the situation described below.



A box of mass $M = 0.4$ kg is moving along a stationary ramp upward ($+x$ direction) as shown in the figure. The box's initial speed $V = 1.4$ m/s. The angle between the ramp and the horizontal plane $\theta = 24$ degrees, and the coefficient of friction between the box and the ramp is $\mu_k = 0.32$.

12) What is the magnitude of the box's acceleration as it is moving up the ramp?

a. $|a_{up}| = 6.9$ m/s^2
b. $|a_{up}| = 7.7$ m/s^2
c. $|a_{up}| = 1.1$ m/s^2
d. $|a_{up}| = 0.85$ m/s^2
e. $|a_{up}| = 4$ m/s^2

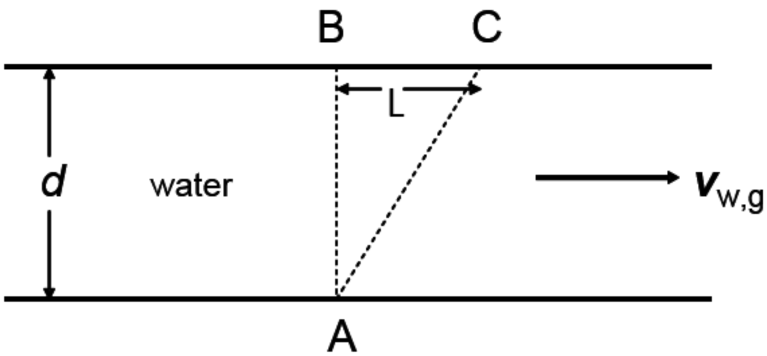
13) What is the direction of the box's acceleration as it moves up the ramp?

a. $+x$
b. $-x$
c. 0

14) Eventually the box is observed to slide back down the ramp with constant acceleration a_{down}. Compare the magnitude of the acceleration of the box going up and down the ramp.

a. $|a_{down}| < |a_{up}|$
b. $|a_{down}| = |a_{up}|$
c. $|a_{down}| > |a_{up}|$

The next two questions pertain to the situation described below.



The width of a river is d = 90 m, the water flows with a constant speed $v_{\mathrm{w,g}}$ with respect to its banks. An athletic swimmer can swim at a speed $v_{s,w}$ = 6 m/s in still water. Although she heads directly across the river toward the opposite bank with her maximum effort, she arrives at point **C** on the opposite bank a distance L = 60 m downstream.

15) The speed of the water, relative to the ground is:

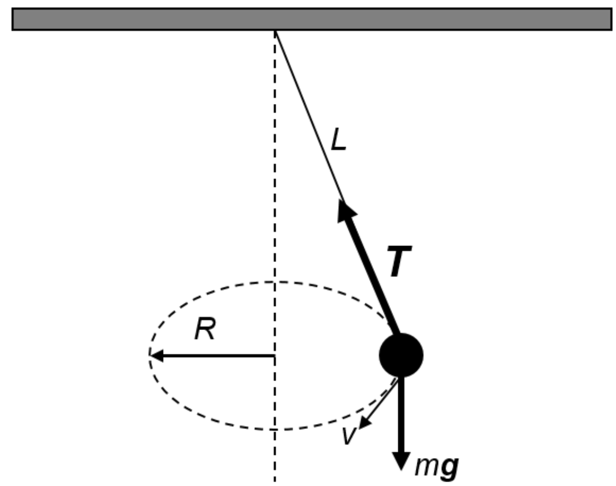
a. $v_{w,g}$= 7.2 m/s
b. $v_{w,g}$= 3 m/s
c. $v_{w,g}$= 6 m/s
d. $v_{w,g}$= 4 m/s
e. $v_{w,g}$= 10 m/s

16) If instead she chose a heading that would get her directly across the river (point **B**), how long would it take her to get to the other side?

a. t = 45 s
b. t = 20 s
c. t = 15 s

The next two questions pertain to the situation described below.

A ball of mass mass $m = 1.5$ kg is suspended from a rope of length L and travels in a horizontal circle of radius $R = 1.8$ m at a constant speed $v = 3$ m/s, as shown in the figure.



17) What is the horizontal component of the tension in the rope $T_{\text{horizontal}}$?

a. $T_{\text{horizontal}} = 15$ N
b. $T_{\text{horizontal}} = 7.5$ N
c. $T_{\text{horizontal}} = 8.3$ N

18) What is the length L of the rope?

a. $L = 2.02$ m
b. $L = 3.96$ m
c. $L = 2.42$ m

The next two questions pertain to the situation described below.

For the following problems assume the earth is a sphere with radius $R_E = 6.4 \times 10^6$ m, and mass $M_E = 6 \times 10^{24}$ kg.

19) If a person weighs 120 pounds on the surface of the Earth, how much would the person weigh on the surface of a planet that has 1/2 of the mass of the earth and 1/2 of the Earth's radius?

a. 120 pounds
b. 60 pounds
c. 240 pounds

20) What is the speed of a 128 kg satelite in a circular orbit around the earth at a distance of $R_{orbit} = 1.92 \times 10^7$ m from the center of the earth?

a. 0.00808 m/s
b. 4570 m/s
c. 1250 m/s
d. 7910 m/s
e. 1.12×10^5 m/s